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Frequency Agile Laser

for

Configurable Optical Networks (FALCON)

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Outline

- **Application Areas**
- **FALCON Program Review**
- **OPLL Implementation**
- **Summarize**

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Application Areas

- **Analog (RF) Photonics**
  - » **Coherent communication systems**
  - » **Optical AWGs**
  - » **Antenna remoting**
  - » **LO distribution**
  - » **True time delay**
  - » **Hybrid fiber radio**

- **Digital Systems**
  - » **Spare DWDM laser inventory reduction**
  - » **Backup for all DWDM transmitters**
  - » **Traffic management/control**
  - » **Intelligent networks (packet switching, etc.)**

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Exploitable Advantages

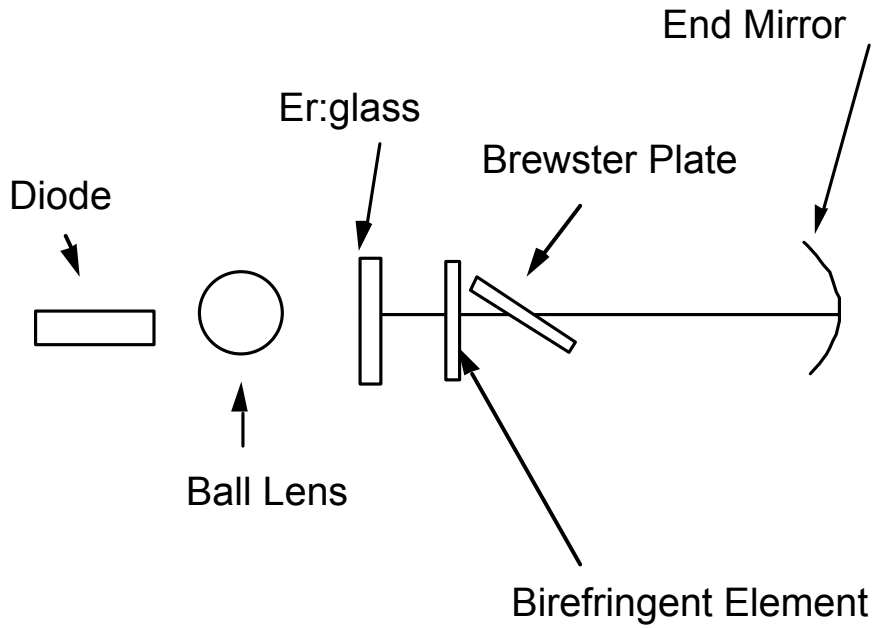
- **Narrow linewidth**
- **Low noise**
- **Rapid tunability**
- **High output power**

- **Mass producible**
- **Low cost**

Basic Laser Technology

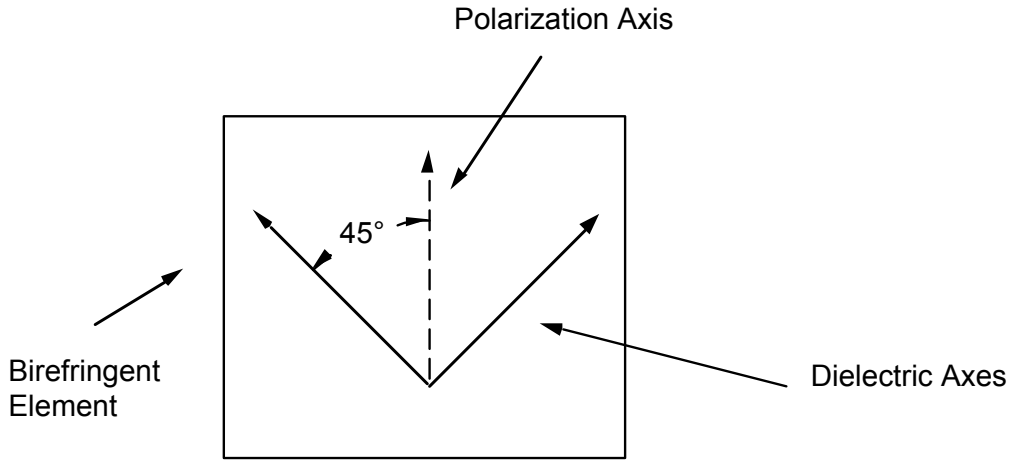
» **Diode-pumped solid-state (DPSS) laser technology**

» **Spatial mode conversion of diode pump source**



- **Erbium-doped glass gain medium**
- **Intracavity components to select functionality**

Single Frequency Performance



- **Er system = Broad gain bandwidth**
- **Birefringent cavity allows large FSR**
- **Combined with polarizer to form a BRF gives strong single frequency selectivity**
- **Proper selection of BRF material allows tunability (thermal, electro-optic)**

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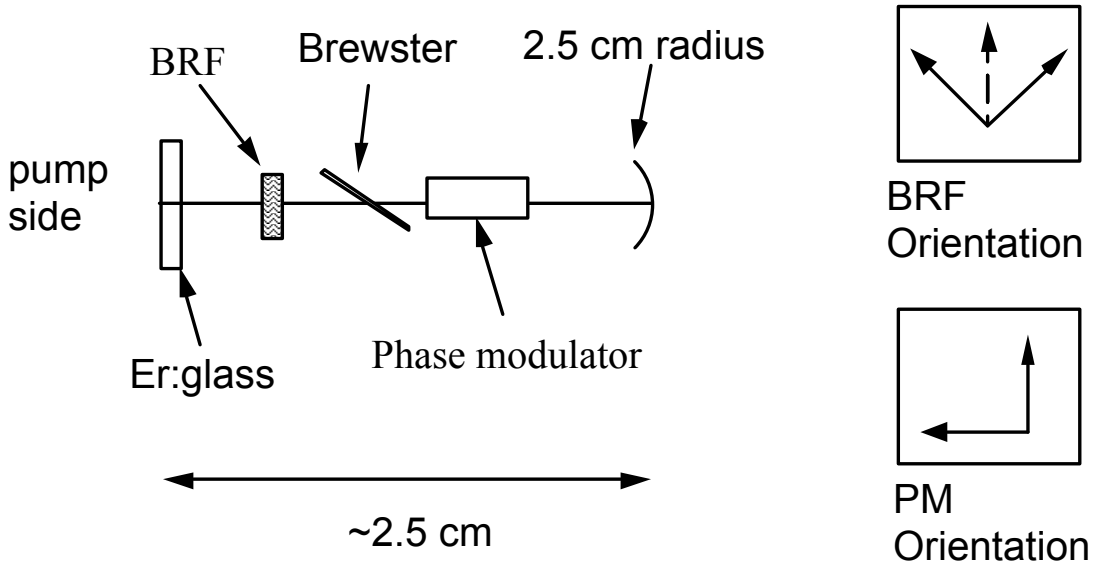
Flexible Tuning Capability

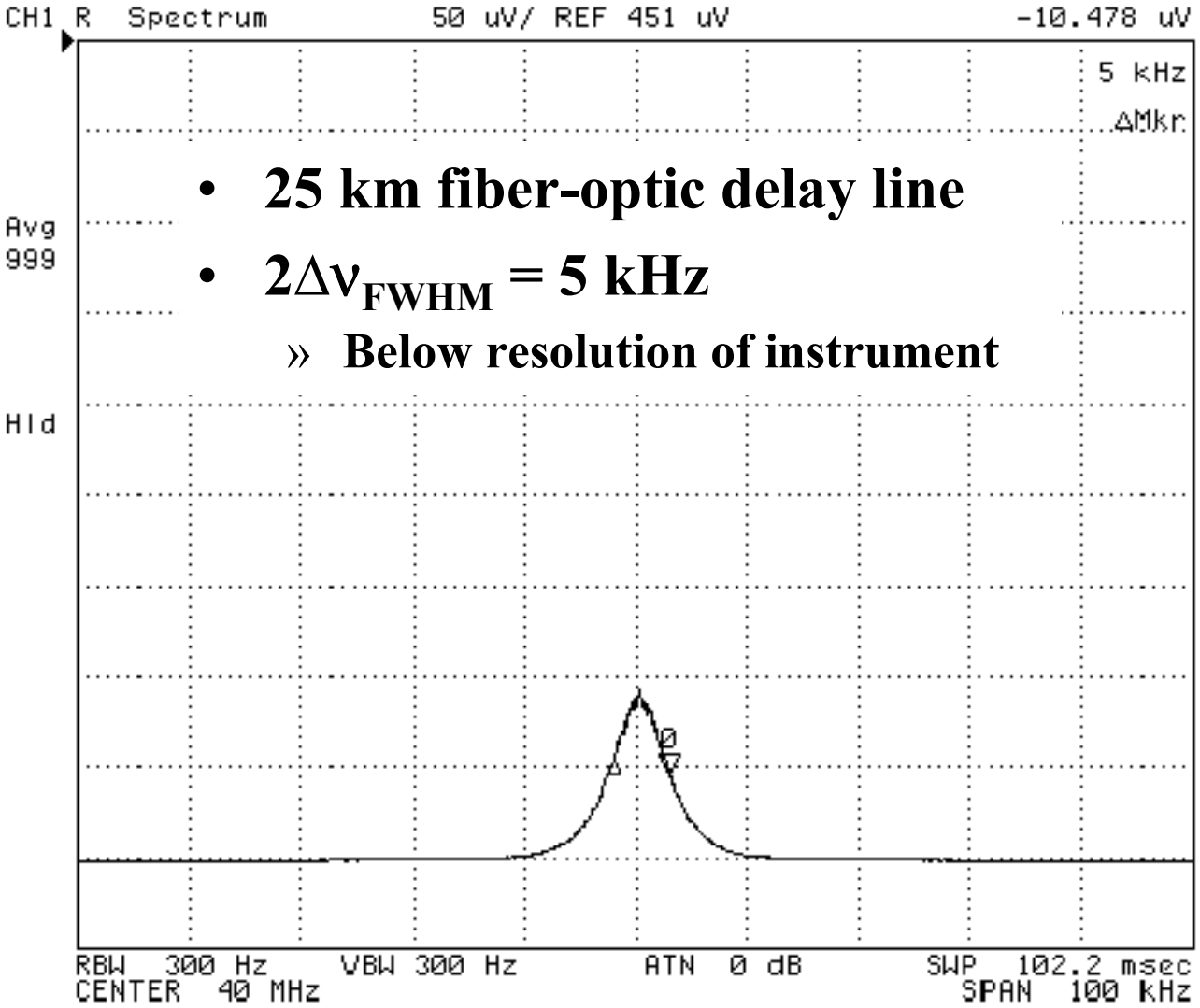
- **Tuning range (10's nm)**
  - » **Gain bandwidth of laser**
  - » **FSR of the BRF**
- **Electro-optic material as BRF allows rapid wavelength switching**
- **Tuning rate**
  - » **Electro-optic device**
  - » **Laser dynamics**
- **Laser currently being designed (Phase I SBIR)**
  - » **Demonstration expected Fall 2001**

FM Tuning Capability



- **Intracavity phase modulator controls the optical frequency by modulating effective cavity length**
- **Simultaneously provides Doppler shift of intracavity field**
- **Electro-optic material provides rapid tunability of laser frequency**

Free-running Linewidth



- **25 km fiber-optic delay line**
- **$2\Delta\nu_{FWHM} = 5$ kHz**
  - » **Below resolution of instrument**

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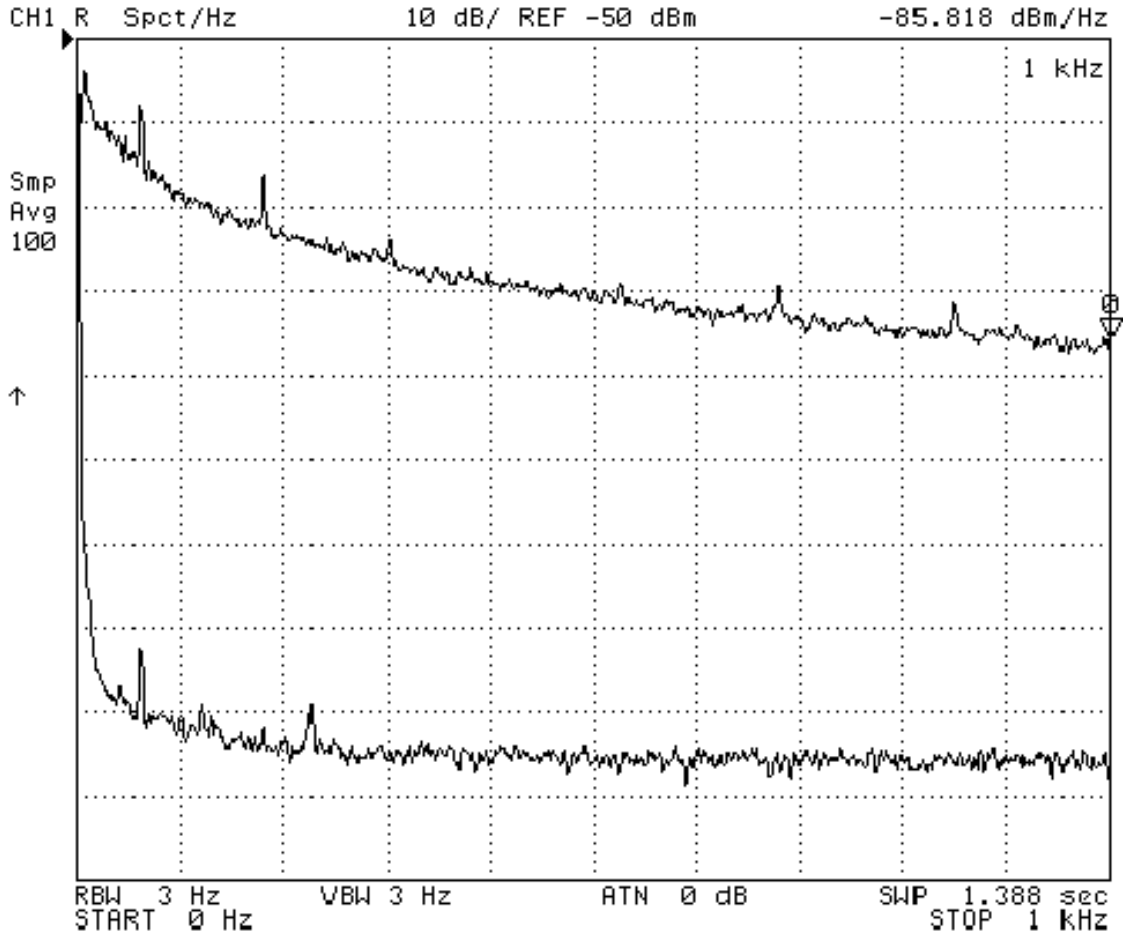
Optical Phase Noise



- **Measured with 100m mismatched interferometer**
- **- 87 dB rad^2/Hz @ 1 kHz**

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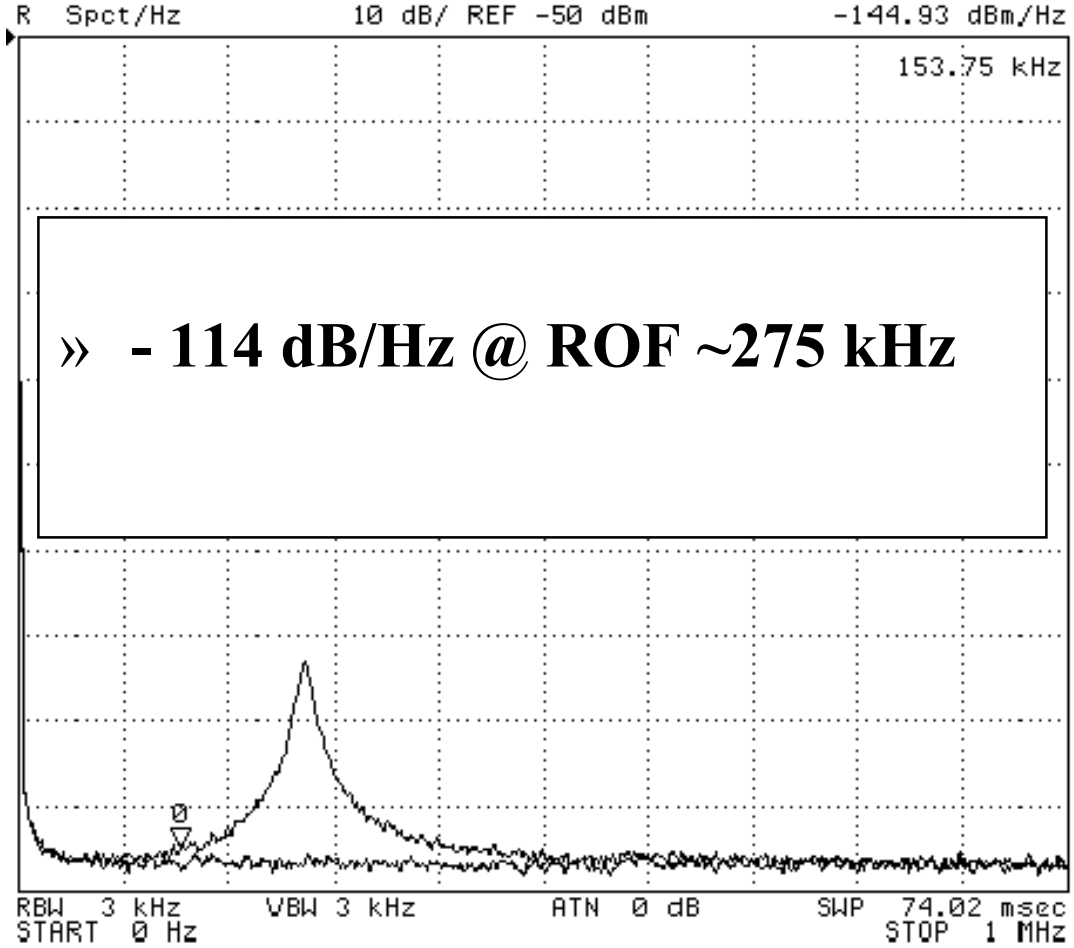
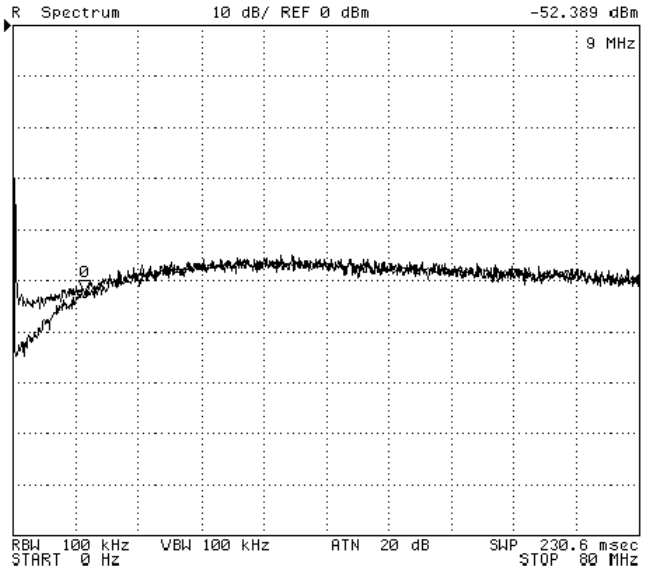
Relative Intensity Noise





Shot noise limited
> 9 MHz (< -170 dB/Hz)

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Broadband Optical Wireless Transmission with Integral Emitters

(BOWTIE)

Nature of Program

Fiber-optically remote transmission of microwave signals

Commercial Significance

Prospects for next-generation optical wireless with low-cost transmission sites

Sponsor

BMDO/AFRL-WPAFB #F33615-00-C-1738

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Photera/UCSD Partnership

- **Photera**
  - » **Source Development**
  - » **OPLL implementation**
  - » **Packaging**
- **UCSD**
  - » **High Speed, High Responsivity Photodiode development and packaging**
  - » **Photodiode Antenna Structure**
- **Joint**
  - » **Analysis of System Phase Noise**
  - » **System Integration, Test, and Evaluation**

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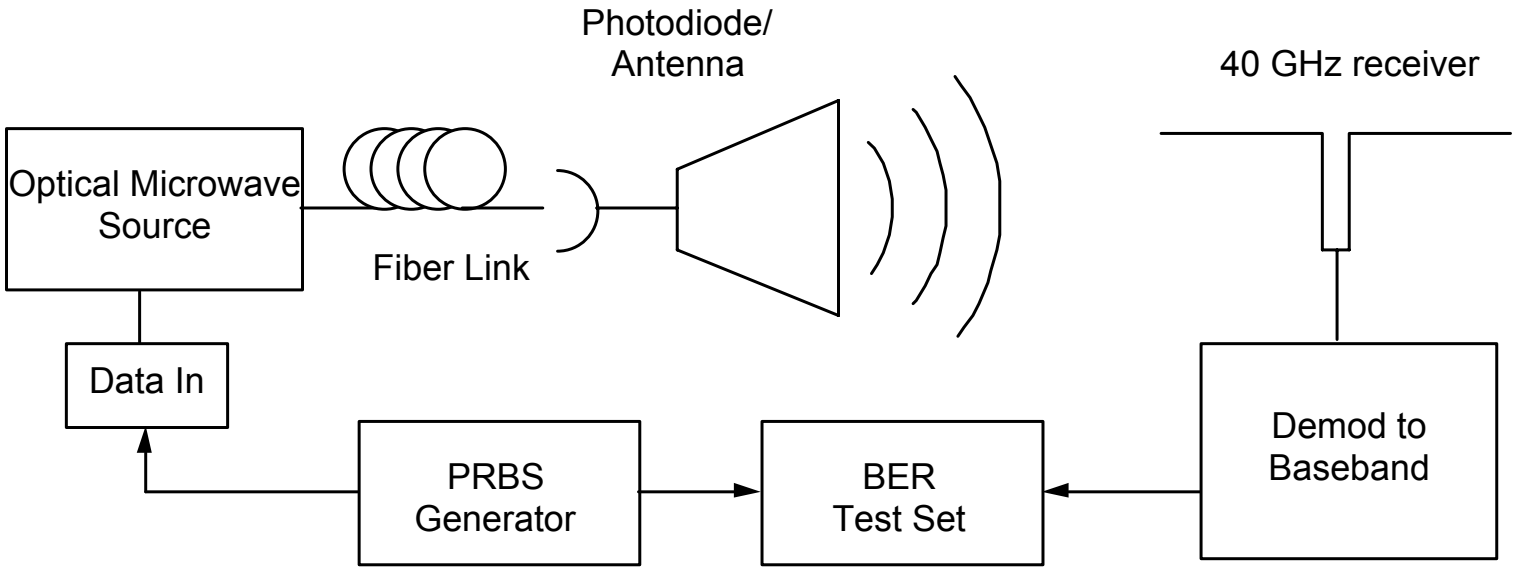
Program Goal



- **Develop low phase noise optical microwave transmitter**
- **Integrate optical source with high efficiency photodetector/antenna**
- **Demonstrate a hybrid optical fiber/wireless link for high data rate communications**
- **Quantify quality of transmission**

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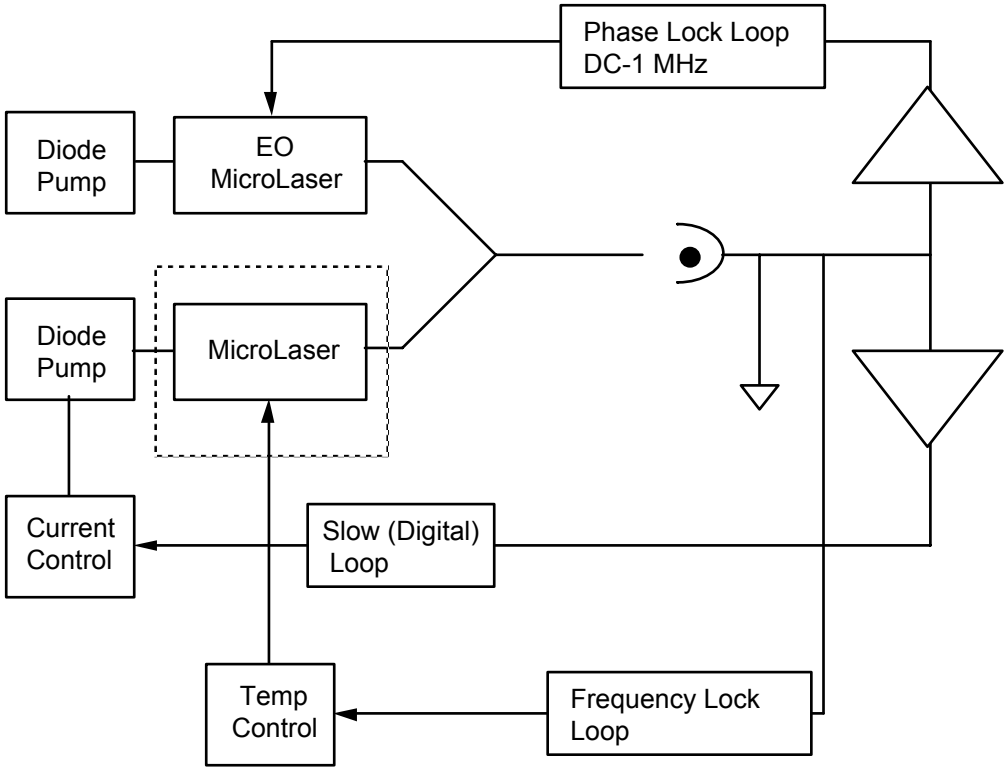
Typical Control Architecture



- **Three tiered loop**
  - » **EO Control: OPLL**
  - » **Wide dynamic range**
    - – **Thermal Control: Frequency Lock Loop**
    - – **Current Control**

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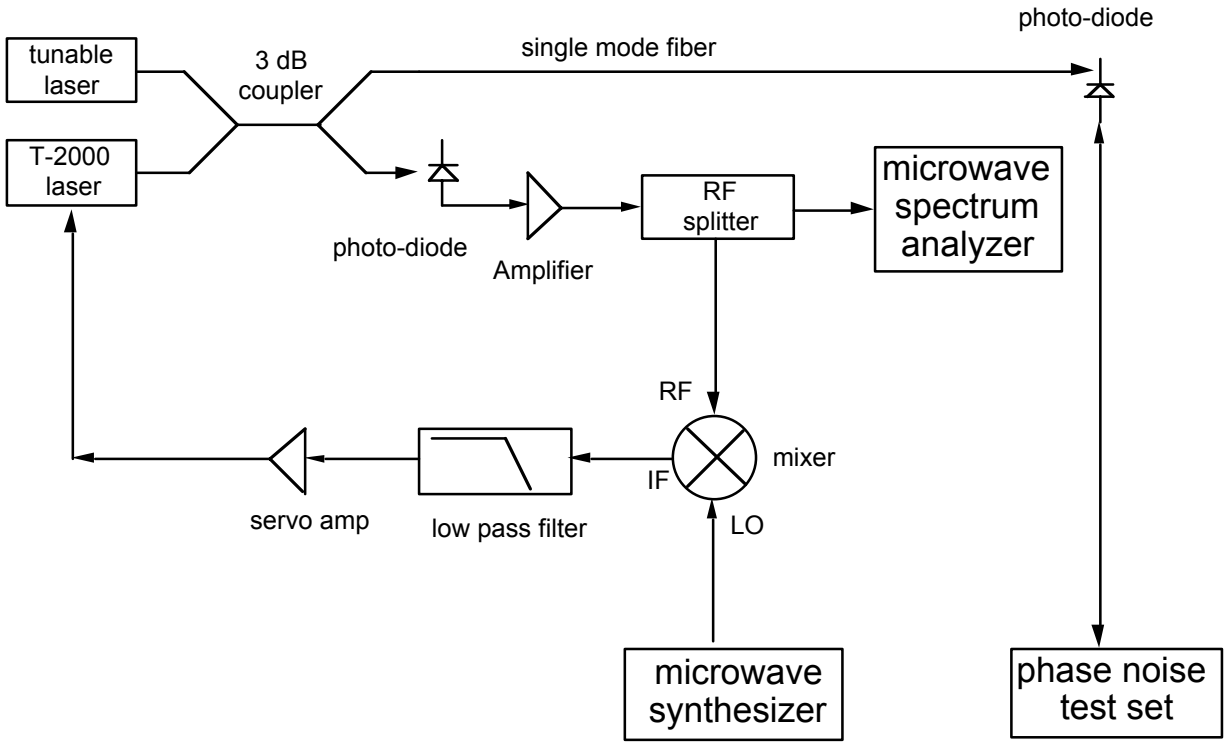
Phase I Testbed



- **Used "old" lasers in OPLL**
- **LPF = 300 Hz**
- **Residual phase noise -110 dBc/Hz @ 10 kHz**
- **Phase II SBIR to demonstrate 20-60 GHz subcarrier**

Summary/Future Work

- DPSS laser technology could provide potential benefits for analog optical systems
- Flexible frequency tuning provides additional functionality

- Further reduce noise sources within laser design
  - » Environmental
  - » FM-AM coupling
- Integrated amplitude and phase modulation
- Combined AM/FM capability while maintaining orthogonality (no crosstalk)
- Should be lower coupling of FM-AM compared to direct semiconductor-based sources